Fisheries and Oceans Canada / Pêches et Océans Canada
Science / Sciences
Central and Arctic Region
Canadian Science Advisory Secretariat
Science Advisory Report 2011/047

ASSESSMENT OF METHODS FOR THE IDENTIFICATION OF CRITICAL HABITAT FOR FRESHWATER MUSSELS

Various freshwater mussel species at risk © DFO

Context :

Critical habitat is defined under Section 2 of Canada's Species at Risk Act *(SARA) as, "the habitat necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species". SARA requires the development of recovery strategies for species listed as Endangered, Threatened or Extirpated under the Act (SARA, Schedule 1). Once designated, SARA provides provisions to protect critical habitat of these species. Current species at risk policies recommend that science information to support the identification of critical habitat in Recovery Strategies and Actions Plans be peer reviewed. A peer review of the conceptual approaches to identifying critical habitat for four Ontario fishes was conducted in May 2008 and these approaches will be considered when developing methods specific to freshwater mussels. However, there has been no peer review related to conceptual approaches for the identification of critical habitat for mussels.*

Fisheries and Oceans Canada (DFO) Science has been asked to provide peer reviewed approaches, and the information required, for the identification of critical habitat for freshwater mussels. In response to this request, a regional science advisory meeting was held on 28 April 2011. This Science Advisory Report results from this advisory meeting and is on the assessment of methods for the identification of critical habitat for freshwater mussels. This assessment considers the scientific information available with which to assess critical habitat for freshwater mussels, and had as objectives to (1) assess the approaches (geospatial delineation, buffer zones, and description of functional habitat) that may be used to identify critical habitat for freshwater mussels; and (2) review, using case studies, a conceptual framework for identifying critical habitat for freshwater mussel species at risk throughout their range that be may adapted for broader usage in riverine and lacustrine systems at different spatial scales.

SUMMARY

- The identification of critical habitat for mussels is comprised of two main components; a geospatial component and a functional description.
- The geospatial component can be delineated using either recovery target-dependent or independent methods. Recovery target-dependent methods have been historically applied using the concept of Minimum Viable Population (MVP), while the recovery target-independent method follows an Area of Occupancy approach.
- Very limited data are currently available to apply the concept of MVP to freshwater mussels; therefore the area of occupancy approach is often more applicable.
- The species-specific functional description plays an important role in the delineation of critical habitat for freshwater mussels by providing a summary of the basic life history and habitat needs of a freshwater mussel to successfully complete each life stage. The functional description should be based on research and literature on the species, if available, or by inference from knowledge of closely related species.
- Guidance related to data quality and quantity, specifically to asses if a record(s) should be considered a population, can be obtained from the Recovery Potential Assessment (RPA) for the species, if a RPA has been completed. If this information is not available from a RPA, or if the recovery team does not agree with the results presented in the RPA, consensus should be reached by the recovery team on what data to include in the delineation of critical habitat.
- Including a buffered area around the area of occupancy should account for the following: (1) uncertainty related to sampling artifacts, taking into account spatial and temporal issues related to sampling; (2) biological considerations, including movement of the mussel and potential movement of the host fish; and (3) that an individual has habitat needs that vary seasonally, and that extend beyond the point of capture.
- The ecological classification buffering approach is generally favoured over a fixed-distance buffer because it provides an opportunity to consider freshwater mussel distribution on a larger spatial scale. Case-specific, appropriate buffering techniques should be applied at the discretion of the recovery team.

BACKGROUND

For a species to be listed under the *Species at Risk Act* (SARA), it must first undergo a listing process. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) completes an assessment and recommends a species to be listed. If a species is listed as Threatened, Endangered or Extirpated under the SARA the competent minister is required to prepare a Recovery Strategy and an Action Plan(s) for the species. The Recovery Strategy must include an identification of critical habitat for the species to the extent possible based on the best available information. Critical habitat is defined under Section 2 of SARA as, "the habitat necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species".

Possible approaches to define critical habitat are required for mussels in riverine and lacustrine habitats. Although some approaches to the identification of critical habitat have been explored using known habitat preferences combined with existing habitat data within a single watershed, such methods are not adaptable to the full range of habitat conditions where species at risk mussels occur.

This science advisory report focuses on methods that may be used by recovery teams to determine critical habitat for freshwater mussels, and is a summary of the Canadian Science Advisory Secretariat peer-review meeting that occurred on 28 April 2011 in Burlington, Ontario. The discussions and associated advice resulting from this meeting are summarized below. Proceedings that provide details of the key discussions of the meeting are also available.

ASSESSMENT

Current guidance associated with the SARA indicates that the identification of critical habitat should be comprised of two main components. The first component is considered to be the geospatial component and can be delineated using either recovery target-dependent or recovery target-independent methods. Recovery target-dependent methods have been historically applied using the concept of Minimum Viable Population (MVP), while the recovery target-independent method generally followed an Area of Occupancy approach. The second component in the identification of critical habitat for mussels is the functional description of the habitat characteristics required by the individual species for each life history stage.

Geospatial delineation

To identify the potential critical habitat for a species, the spatial distribution of the species must be known. The current distribution of the species is assumed to represent the minimum spatial extent of the areas that are likely to have the necessary elements for the recovery and survival of the species. Although our understanding of the distribution of each species is likely not representative of the true distribution of the species, we must use the known distribution of the species as a starting point. When delineating the spatial extent one must consider data quality of the points of occurrence as well as differences between historic and current records. Once the spatial extent has been determined it is necessary to determine which habitats within the extent are important to the species. The spatial extent can be delineated geospatially by applying either recovery target-dependent or recovery target-independent methods.

Recovery target-dependent

Recovery target-dependent methods are typically related to MVP targets, which are the smallest possible sizes at which populations can exist without facing extinction from demographic or stochastic variability. For freshwater fishes, MVP is generally multiplied by an area per individual (API) estimate to obtain the minimum area required for population viability (MAPV) (Vélez-Espino *et al.* 2010). Although MPV targets and MAPV estimates have been used to aid in the delineation of critical habitat for freshwater fishes, very limited data are available to apply this type of approach to freshwater mussels. In addition, API equations do not currently exist for freshwater mussels. A possible alternative to utilizing API equations could be to use known density estimates. For example, if a density estimate was available for a species and the proportion of aquatic system composed of suitable habitat was also known, the total habitat required could be estimated; although, it should be noted that this approach would assume that the densities observed represent sustainable populations.

MVP values have been calculated for two Wavy-rayed Lampmussel populations (Young and Koops 2010); however, it is believed that this may be the only freshwater mussel in which sufficient information and data are available to estimate MVP values. Although the MVP approach may be appropriate for freshwater mussels, the lack of sufficient information to calculate the necessary estimates excludes this recovery target-dependent approach from being

a viable option for most species to determine the geospatial extent necessary in the delineation of critical habitat.

Recovery target-independent

The recovery target-independent approach is an alternative to the MVP approach when the lack of population data precludes its use. The recovery target-independent approach allows for the inclusion of both historical and current distributions or any combination of the two. It is generally referred to as an area of occupancy approach. The three area of occupancy approaches considered included:

1. a minimum convex hull polygon (Figure 1a);
2. a geographic feature envelope (Figure 1b); and
3. a whole waterbody approach (Figure 1c).

The convex hull polygon is the simplest measure of the minimum wetted area encompassing all known distribution points. It results from drawing a polygon around the points of occurrence while ensuring all sides remain convex. Although a simple approach that may not best represent the area of occupancy in water bodies with complex shapes it benefits from being closely aligned with the methods used by COSEWIC to assess species status. The second approach, the geographic feature envelope approach, is based on the distribution of points where the species is known to occur (Figure 1b). In this approach, the area of occupancy is designated as a rectangle projected around the points of occurrence based on the minimum and maximum latitude and longitude values. The third approach is the whole waterbody approach (Figure 1c). This type of approach is generally more applicable in situations where the points of occurrence are found within a relatively contained area (e.g., a small lake or bay).

Data quality

One of the major obstacles when delineating the geospatial area of occupancy is determining which data should be included as valid occurrence points. For example, one must decide what time period should be considered, historic or current. In many cases, a cutoff is applied that represents the timeframe when concerted efforts to sample freshwater mussels, applying standardized methods, began. In southern Ontario, the mid- to late-90s indicates the point where standardized sampling practices began; and, therefore is often used as the starting point for reliable data records. In addition, the standardized sampling from this time period did included the state of the animal (live, fresh shell, weathered shell), which was not necessarily the case for older records.

In situations where historic records exist, but recent sampling has indicated that the population no longer occupies the area, two things must be taken into consideration: (1) is the habitat still suitable to be considered in terms of recovery habitat, or could it be restored/improved to this level; (2) is there a possibility that the mussel still persists in the area and recent (possible limited) sampling has simply not detected the presence of the species. In reference to the first consideration, it is important to determine if the habitat could be used to meet population and distribution objectives for the species, or if there are current abiotic and/or biotic factors present that preclude the use of this habitat by the species.

Ideally, information related to whether or not a population should be considered extant or extirpated would be provided through the RPA process. If a RPA has not been completed for a species, the decision to include or exclude a population from the area of occupancy will be made by the recovery team for that species.

(a)

(b)

(c)

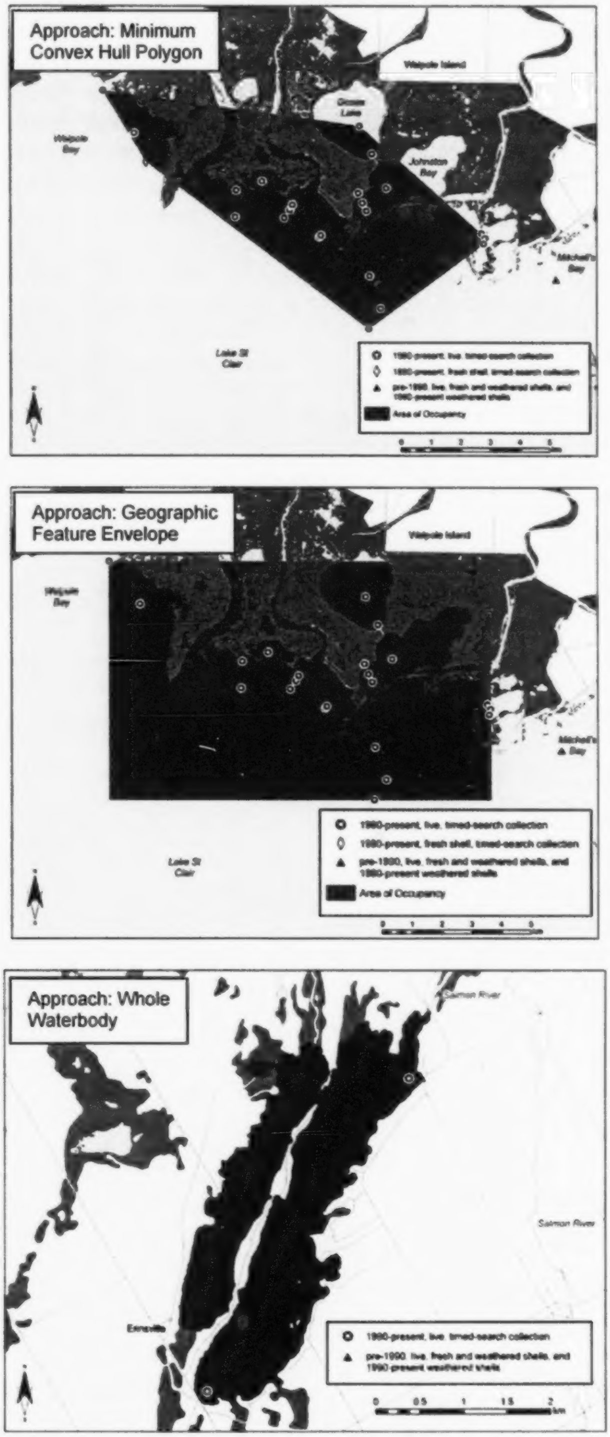

Figure 1. Examples of recovery target-independent approaches to delineating geospatially the area of occupancy of a species including (a) minimum convex hull polygon, (b) geographic feature envelope and (c) whole waterbody.

Buffering

Once the current area of occupancy of a species has been determined (based on location of capture), decisions related to the application of a buffer zone must be made. Considerations to keep in mind should include whether a buffer should be applied, and if so, which method should be used to determine the size and shape of the buffer. Buffering an area could account for the following:

1. uncertainty related to limited sampling (spatially and/or temporally);
2. biological considerations, including movement of the mussel and potential movement of the host fish;
3. that an individual may have habitat needs, that may vary seasonally, that extend beyond the point(s) of capture; and
4. other (unspecified) sources of uncertainty.

Three generic buffering methods were considered including: (1) fixed distance/fixed area buffers; (2) buffering using an ecological classification system; or (3) applying a host-dependent buffer.

Fixed Distance Buffer

The fixed distance buffer involves applying a standard buffer from a point of occurrence. This method is based on the COSEWIC area of occupancy[1] approach where a 1 km^2 grid cell is used as the minimum resolution for estimating area of occupancy for freshwater species. Application of the 1 km^2 grid cell results in a 500 m radius buffer around the point of capture (Figure 2). A criticism of the COSEWIC grid cell approach is that it inevitably results in large areas of unsuitable habitat (i.e., terrestrial habitat) being included in the area of occupancy for aquatic species. As a result, a modified version of this approach was discussed; rather than maintaining a set radius (i.e., 500 m) around a point of occurrence, the equivalent area of a circle with a 500-m radius was determined around the point of occurrence, thereby ensuring that all areas within the buffer were located in water and followed the natural shoreline. This modified fixed area buffer would ensure that only contiguous wetted area would be included in the area of occupancy.

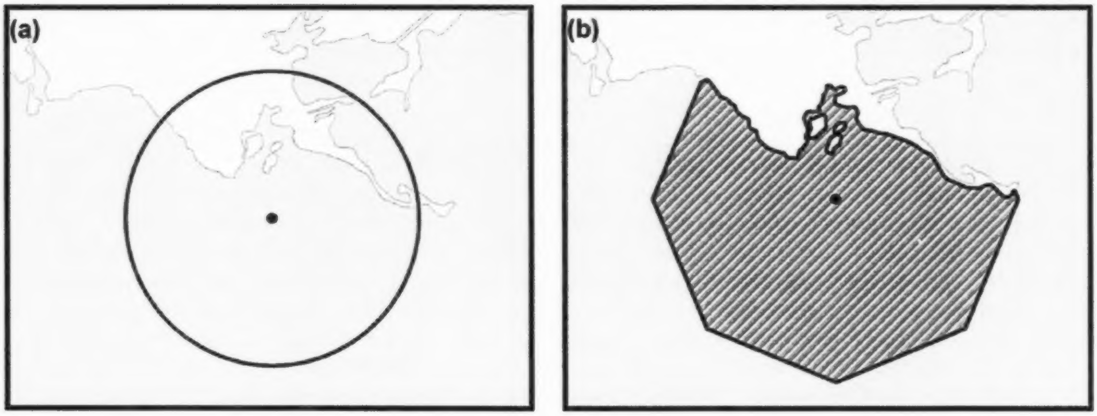

Figure 2. Buffering the area of occupancy by (a) a fixed radius buffer represented by a vector polygon, and (b) a fixed area buffer represented by a raster grid..

[1] http://www.cosewic.gc.ca/eng/sct2/sct2_7_e.cfm; Accessed 25 May 2011

Ecological Classification Buffer

Buffering by applying an ecological classification (EC) was also considered. The ecological classification represents a homogenous habitat type based on variables important to the species; therefore, if a species is present within a distinct ecological class, there is no reason to believe that it would not be found in other spatially contiguous areas of the same class. Specifically, if an ecological classification system does exist at the appropriate scale, the species range can be estimated as the entire extent of the spatially derived class in which at least one record is present. A commonly applied ecological classification system for riverine systems in Ontario is the Aquatic Landscape Inventory System (ALIS) and defines stream segments based on a number of unique characteristics, such as hydrography, surficial geology, watershed class, drainage area, connectivity, slope, climate, land cover and barriers (Figure 3; Stanfield and Kuyvenhoven 2005). Although ALIS was discussed as a commonly used EC approach and applied for illustrative purposes, it should be noted that the merits of this inventory system were not scientifically peer-reviewed. The EC approach is generally favored because it provides an opportunity to consider freshwater mussel distribution, an area of study that is fairly data-poor, on a larger scale. Unfortunately, there are very limited commonly-accepted EC systems available for lotic systems and even fewer for lentic systems. The decision of which EC system to apply should be considered by the recovery team on a case-by-case basis.

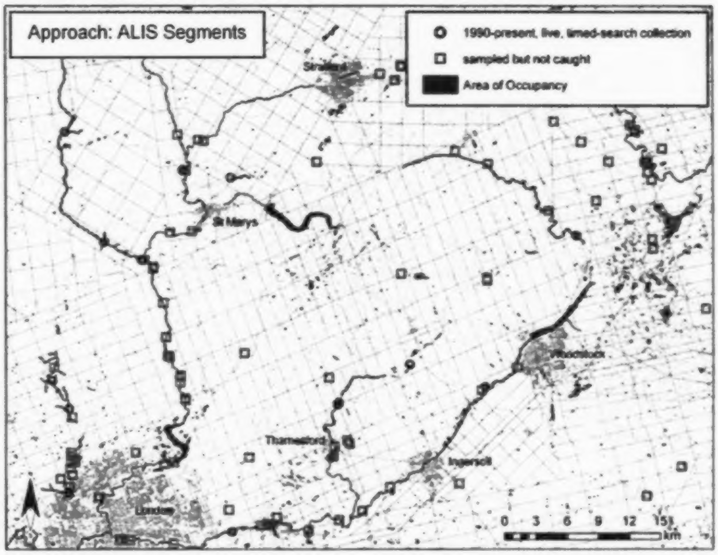

Figure 3. Buffering the area of occupancy by applying the Aquatic Landscape Inventory System (ALIS), an ecological classification system. The ALIS segments used in classifying the area of occupancy are highlighted in red.

Host-Dependent Buffer

The unique life history of freshwater mussels, in that they are obligate parasites during the glochidial stage, provides support for the use of a host-dependent buffer. Since mussel dispersal is tightly linked to host movement, buffering the range of mussel occurrences by the home range of the host fish may be a suitable approach (Newton *et al.* 2008). Potential habitat available for the offspring of any given female mussel includes not only the habitat currently occupied by the female but also any suitable habitat within an area encompassing the home range of the host fish(es). It is difficult to provide clear direction on how best to incorporate the host distribution and home range as a buffer since the host is generally much more widespread than the mussel. Specifically, the host distribution may not be limiting the mussel distribution

and there is very little evidence of host limitation for freshwater mussels in Ontario. Although the host should be considered as a component in the creation of a buffer of area of occupancy, clear direction on how this could be accomplished was not decided.

Case Studies

Several case studies were used to illustrate the range of aquatic systems occupied by freshwater mussels (Figure 4) and the various types of approaches, discussed above, that may be used to delineate area of occupancy. All examples described below were used to illustrate a generic species distribution scenario; therefore, the name of the species has not been included. It should also be noted that additional hypothetical sampling points have been added to some of the scenarios for discussion purposes; the maps are not true representations of freshwater mussel distribution. It is the ultimate decision of the recovery team whether an area can be used as recovery habitat and may be identified as critical habitat to meet population and distribution objectives. The following maps and approaches are not meant to be prescriptive and the final designation of critical habitat is to be made by the recovery teams.

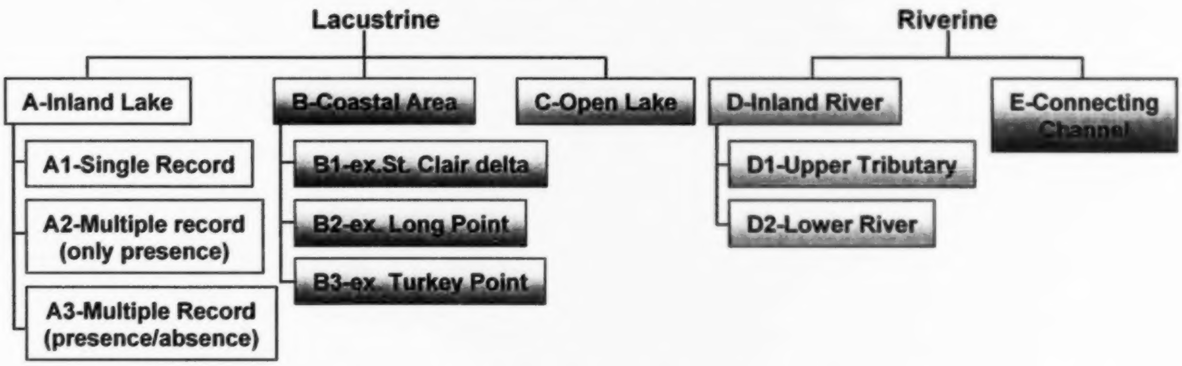

Figure 4. Framework of the different habitat types and scenarios that may be encountered when delineating critical habitat for freshwater mussels in Ontario.

A - Inland Lake

Single Record (Figure 5):

- Determination of whether or not a record is indicative of a reproducing population, and therefore could be used in the identification of critical habitat, should be obtained from the RPA process.
- If a RPA has not been completed for the species, the recovery team should apply the following guidelines:
    - If a single record represents a single individual, there is not sufficient evidence of a reproducing population and critical habitat should not be identified.
    - If a single record represents more than a single individual and the individuals represent various age classes (indication of recruitment) the whole waterbody approach should be applied until additional data are acquired indicating otherwise.

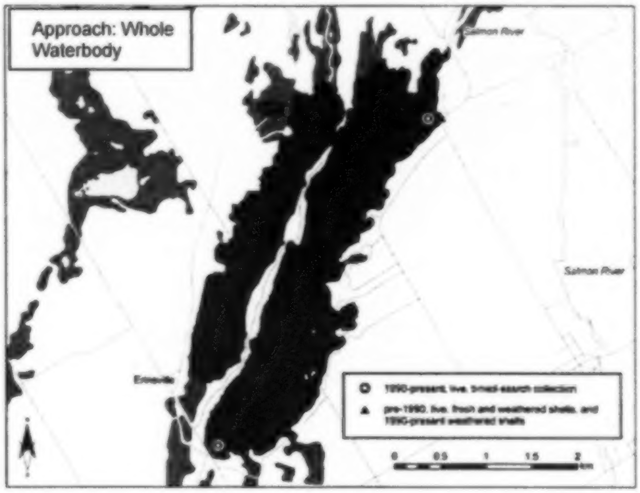

Figure 5. Hypothetical example of a scenario where the whole waterbody approach to identifying critical habitat is applied.

Multiple Records (only presence) (Figure 6):

- Determination of whether multiple records is indicative of a reproducing population, and therefore could be used in the identification of critical habitat, should be obtained from the RPA process.
- If a RPA has not been completed for the species, the recovery team should apply the following guidelines:
  - o If individuals from multiple records do not represent various age classes and there is no evidence of recruitment, it can not be determined if records represent a population and critical habitat should not be identified.
  - o If individuals from multiple records represent various age classes (indication of recruitment) the whole waterbody approach should be applied (Figure 6) until additional data are acquired.

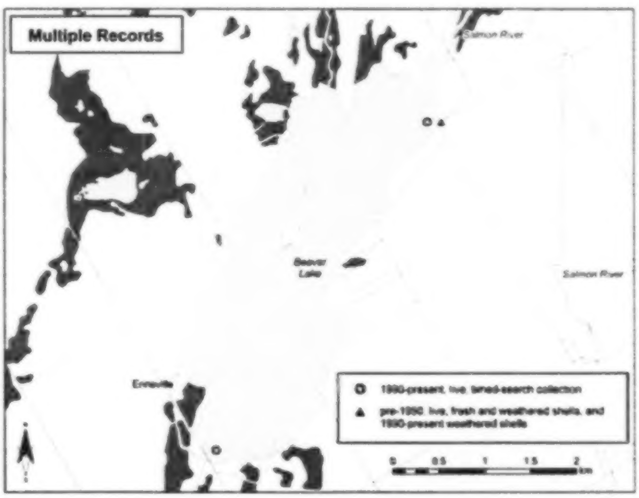

Figure 6. Hypothetical example of a case study of multiple records, representing only presence data, in an inland lake.

Multiple records (both presence and absence data) (Figure 7):

- Determination of whether multiple records is indicative of a reproducing population, and therefore could be used in the identification of critical habitat, should be obtained from the RPA process.
- If a RPA has not been completed for the species, the recovery team should apply the following guidelines:
    - If individuals from multiple records do not represent various age classes and there is no evidence of recruitment, it can not be determined if records represent a reproducing population and critical habitat should not be identified.
    - If individuals from multiple records represent various age classes (indication of recruitment) the whole waterbody approach should be applied (Figure 6) until additional data are acquired.
- In addition, any available habitat characteristics related to presence and absence data should be used to analyze potential correlations between habitat and species presence and absence. Habitat correlations may subsequently be used to further refine the functional description of the species, and subsequently aid to exclude regions of the lake that may not be suitable, leading to the refinement of critical habitat identification.

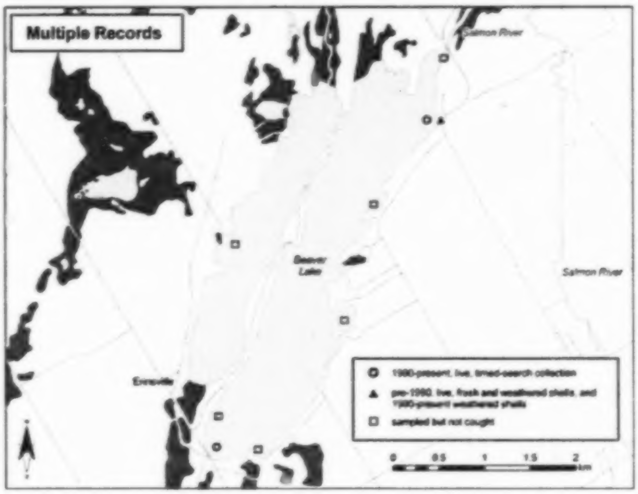

Figure 7. Hypothetical example of a case study of multiple live records, as well as sampled but not caught records, in an inland lake.

<u>B – Coastal Area</u> (Figure 8)

- Coastal areas represent a specific challenge when identifying critical habitat as they are generally too large to apply a whole waterbody approach.
- Ecologically-significant, species-specific habitat preferences (e.g., depth preference, substrate preference, zebra mussel free habitat) should be used to determine the area to be identified as critical habitat.
- Areas that have been sampled with appropriate sampling effort and methods would play a particularly important role in determining areas that may be excluded from critical habitat delineation. In addition, known hydrological preferences (e.g., a species is known to only inhabit habitats with specific flow regimes or depths) may be used to aid in the delineation of cut-off points (i.e., location where a riverine system transitions into a lacustrine system).
- In the absence of any ecologically significant classification system, areas where habitat is known to be similar to habitat where species is found should be included in critical habitat

delineation, until additional sampling can be completed to verify species presence or absence.

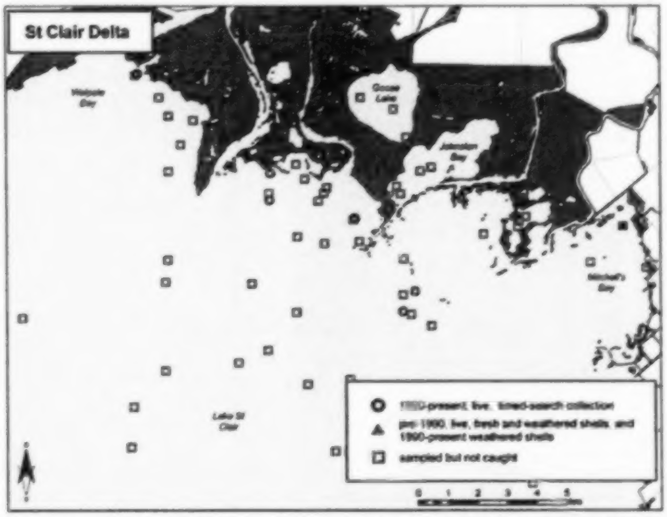

Figure 8. Example of a case study of multiple records, representing both species presence and absence, in a coastal wetland system.

C – Open Lake

In light of the current state of freshwater mussels in the open waters of the Great Lakes it was decided that a discussion related to the identification of critical habitat in these systems may be too hypothetical to discuss and consider. Advice was not provided for this habitat type.

D – Inland River

Upper Tributary (Figure 9):

- The recommendation is to apply an ecological classification system, such as ALIS.
- A segment would be identified as critical habitat if a point of occurrence is found within the segment (acceptance of a data point would be related to above discussion on data quality).
- If a segment between two segments identified as critical habitat has been sampled (with standardized sampling techniques and effort that are deemed acceptable by the recovery team) and the species was not detected, the segment would not be identified as critical habitat.
- If a segment between two segments identified as critical habitat has not been sampled and there is no information available that the species is not present in this segment, the segment would be identified as critical habitat.
- If a segment between two segments identified as critical habitat has not been sampled, there is no information available that the species is not present in this segment, but it is known that the habitat within the segment does not align with the known preferred habitat of the species, the decision would be left with the recovery team as to whether or not the segment should be identified as critical habitat.
- If a segment identified as critical habitat flows through a lake, the decision to identify the lake as critical habitat would be considered on a case-by-case basis taking into consideration the functional habitat of the species and whether it was known to occupy lacustrine systems, as well as riverine systems.
- If the point of occurrence is located at the edge of a segment identified as critical habitat, it would not be appropriate to include the next segment in its entirety, but may be

precautionary to include a biological buffer (i.e., fish home range) from the point of occurrence extended into the next segment.

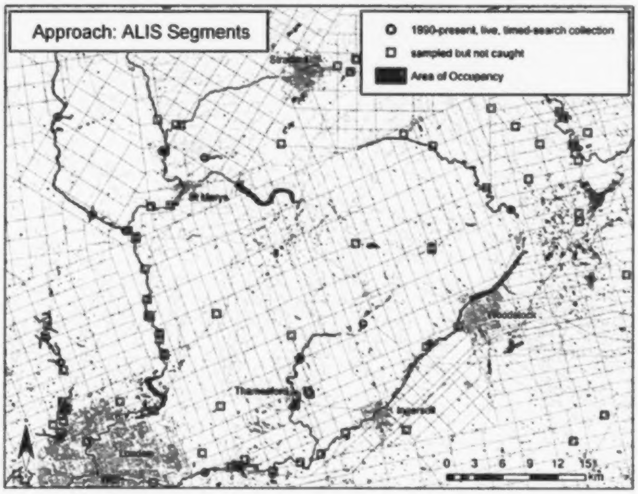

Figure 9. Example of a case study of applying an ecological classification system to delineate area of occupancy in the upper tributaries of a river system.

D – Inland River

Lower River (Figure 10):

- The recommendation is to apply an ecological classification system, such as ALIS.
- All recommendations from the upper tributary case study related to the application of using an ecological classification system would also apply to lower rivers.
- It should be considered that the river may be acting as a source for riverine freshwater mussels that may be able to survive in the transition area between the river and the lake.
- If a point of occurrence is located at the lake/river interface (i.e., either at the river mouth but within the river, or within the lake proper) an ecological buffer should be applied to all occurrence points that may extend the area of occupancy into the lake.

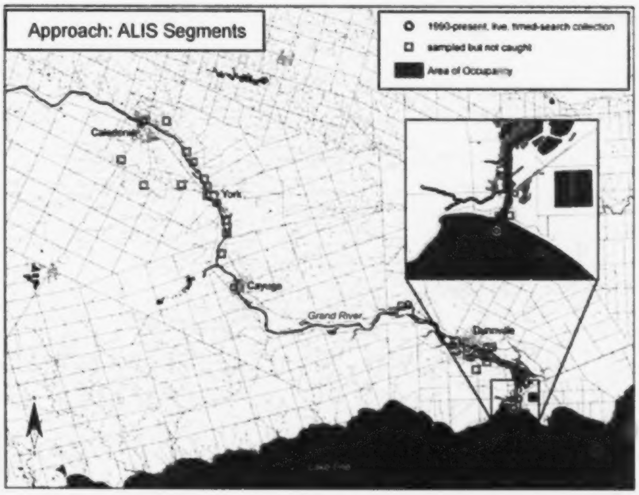

Figure 10. Example of a case study of applying an ecological classification system to delineate area of occupancy in the lower portion of a river system.

E – Connecting Channel

- Connecting channels should be treated similarly to coastal areas.

Functional Description

Functional description plays an important role in the delineation of critical habitat for freshwater mussels by providing a summary of the basic life history and habitat needs of a freshwater mussel to successfully complete each life stage. Specifically, the functional description may provide rationale for the inclusion of areas outside of those where the species is known to exist (i.e., points of occurrence). Conversely, the functional description may help in excluding areas that do not meet the functional requirements of the species. The functional description should be based on research and literature on the species, or if insufficient information is available for the species, it may be inferred from closely related species.

For freshwater mussels, it was decided that the functional attributes associated with two life stages should be considered: adult/juvenile and glochidial. Resulting from a lack of evidence to support the separation of juvenile and adult life stages, and the substantial overlap in preferred habitat, these two life stages were grouped together. However, the functional attributes related to adult/juvenile and glochidial life stages vary significantly and should be considered separately.

The following is a list of attributes that have been highlighted as being of particular importance to freshwater mussels, and should, at a minimum, be considered when discussing attributes of critical habitat for freshwater mussels.

Attributes associated with the adult/juvenile life stage

- Substrate
  - Composition (particle size)
  - Compactness
  - Stability
- Fluvial geomorphology (rivers)/coastal processes and sediment transport (lentic)
  - Riffle, run, pool
- Water quality
  - Turbidity and suspended solids
  - Dissolved oxygen
  - Pollutants
  - Metals
- Flow rate
  - Maximum flow rate, minimum flow rate, optimal or preferred flow rate
  - Current velocity
- Preferred water depth
- Food source
- Biological pressure – Negative influence from aquatic invasive species (i.e., Zebra Mussel, Round Goby)

Attributes associated with the glochidial life stage

- Host species
- Timing of fertilization
- Timing of glochidial release
- Host density and community composition, if more than one host fish is used

- Size/age of host fish
- Size/age of mussel
- Level of immunity of host fish

CONCLUSIONS

The identification of critical habitat for freshwater mussels should be comprised of both a geospatial component and a functional description. Until additional data can be acquired on life history parameters to inform recovery target-dependent methods, recovery target-independent methods, such as an area of occupancy approach, should be used to inform the geospatial component. The type of area of occupancy approach and buffering technique to be applied should be related to the type of aquatic system being considered. Case studies provided in this document can be used as general guidance when determining which type of area of occupancy method and buffering technique to apply. Data quality issues related to reliability of data and whether specific records should be considered representative of populations should be obtained from the RPA process. In cases where this information is not available, the decision to include or exclude a record from the area of occupancy of a species will be decided by the recovery team for that species. Ideally, for freshwater mussels, a functional description of the attributes necessary for both the adult/juvenile life stage as well as the glochidial life stage will be provided. The functional description can be used to provide rationale for the inclusion of area outside of those where the species are known to exist, or conversely, may help in excluding area that do not meet the functional requirements of the species. If the attributes used to inform the functional description are unknown for a species, additional research and analyses should be completed to decrease the level of uncertainty related to these attributes.

SOURCES OF INFORMATION

This Science Advisory Report is from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, regional advisory meeting of April 28, 2011 on the assessment of methods for the identification of critical habitat for freshwater mussels. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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Internet address: www.dfo-mpo.gc.ca/csas

ISSN 1919-5079 (Print)
ISSN 1919-5087 (Online)

La version française est disponible à l'adresse ci-dessus.

CORRECT CITATION FOR THIS PUBLICATION

DFO. 2011. Assessment of Methods for the Identification of Critical Habitat for Freshwater Mussels. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/047.